Radiographical Evaluation of Styloid Process (A Comparative Study Between Panoramic and Skyview Cone Beam Computed Tomography) In Iraqi Population

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Abstract: Purpose: This study was performed to compare the lenght, morphology, and calcification pattern of the elongated styloid process and its relation to age between panoramic and skyview cone beam computed tomography in the Iraqi population. **Materials and Methods:** The study analyzed digital panoramic and skyview images of 20 subjects. The elongated styloid process was classified with the radiographic appearance based on the morphology and calcification pattern. The data were analyzed statistically. **Results:** Chi-square between elongation patterns type and calcification patterns type in panoramic showed statistically significant difference as same as in skyview images with (p-value = 0.042, p-value = 0.047) respectively.Chi-square between panoramic and skyview images by age groups of calcification patterns type demonstrated statistically significant difference with (p-value = 0.046). **Conclusions:** Dentist should recognize the existence of morphological variation in elongated styloid process or Eagle syndrome apparent on panoramic radiographs and skyview images.The calcification of styloid process was more common in the older age group and type I was observed more frequently in the population studied.
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Keywords: Styloid process,panoramic, 3D panoramic images, calcification.

Abbreviations: SP, Styloid process; **CBCT**, Cone-beam computed tomography; **PR**, Panoramic radiography; **ES**, Eagle's syndrome; **SHL**, Stylohyoid ligament; **ESP**, Elongated styloidprocess; **CT**, Computed tomography; **3-D**, Three-dimensional.

1. Introduction:

The name styloid process (SP) was derived from the Greek word'stylos' meaning a pillor. Embryologically SP, the stylohyoid ligament and the lesser cornu of hyoid bone are developed from the second brachial arch called Reichert' s cartilage. Because the cartilaginous origin the ligament has the potential to mineralize **(Shah et al., 2012).** The styloid process is a cylindrical, long cartilaginous bone located on the temporal bone in front of the stylomastoidforamen. Many nerves and vessels such as thecarotid arteries are adjacent to the styloid process **(Bagga et al., 2012)**.The normal length of styloid process is approximately 20-30 mm. The styloid process length which is longer than 30 mm was considered to be elongated styloid process **(Ilgüy et al., 2005).** Studies it varies in length from person to person and even from side to side in the same person **(Egle, 1937).**

Panoramic images are most useful clinically for diagnosing disorders related to facial structures including maxillary and mandibular bones and their supporting structures **(Jung et al., 2004; Lurie, 2004; Kursoglu et al., 2005; Gokce et al., 2008b)**. Panoramic radiography is useful for detection of an elongated styloid process and/or ossification of stylohyoid ligaments in patients with or without symptoms and can thus help avoid misinterpretation of the symptoms and hence panoramic radiography is an economical and best imaging modality to view the elongation of styloid process **(Priyadarshini et al., 2013).**

Three dimensional images is an effective method in the evaluation of the styloid process length, angulations and other morphological characteristics **(Basekim et al., 2005).** More commonly; a panoramic radiography is used to determine whether the styloid process is elongated, computed tomography is useful for complementary information to that provided by panoramic **(Rechtweg and Wax, 1998; Murtagh et al., 2001**; **Gokceet al., 2008a).** Although panoramic radiographs have an important role for demonstrating the variations of styloid process, they are not able to show the orientation and dimensions of this bone. On the other hand,multislice computed tomography (MSCT) provides a reliable visualization of this features **(Ramadan et al., 2007).**

In the last decade,CBCT has been recommended as an excellent, low-cost tool for the evaluation of these anatomical structures with only slightly more radiation than panoramic radiographyand far less than

a CT scan **(Orhan et al., 2013).** Compared to conventional two dimensional techniques, CBCT imaging presents as main advantages the elimination of superimposition of neighboring structures and absence of image magnification, this recently-designed technology has become a relevant tool for diagnostic imaging of oral and maxillofacial osseous structures, providing to professionals access to excellent image quality and greater diagnostic accuracy and sensitivity **(Scarfe et al., 2006).**

In present study used Skyview adopts a new and increasingly successful X-ray technique, known as Cone Beam Computed Tomography (CBCT), ideal for obtaining three- dimensional reconstructions of teeth and the entire maxillofacial area, skeyview has the advantage of acquiring images with just one partial rotation of the source-detector system around the patient. Consequently, less time is needed to perform the examination and, above all, the patient is exposed to a considerably lower X-ray dose.

2. Materials and Methods:

Panoramic radiograph and skyview cone beam computed tomography of 20 subjects were showed measurable styloid process. These radiographs were obtained from panoramic system (My ray CE 0051(V.B1 cocc A 14/C-IMOLA (BO)-Italy, X-ray source (85kVp, 10 mA), exposure time (18 sec). Skyview cone beam computed tomography (My ray: Italy, X-ray beam (conical, variable-field (H.R. Zoom)), X-ray source (90 kVp, 10 mA (max), pulsed emission), image detector (high resolution intensifier-digital CCD sensor 1000 × 1000- pixel 7.4 μm), thickness of axial tomography sections(starting from 0.05 mm), class (electro-medical equipment-Class IIb (CCE 93/42,annex IX). The following were measured or determined for each styloid process identified: length, type and the pattern of calcification, the right and left side styloid processes were analyzed independently. The length of styloid process was measured in a similar method, described by Ilgüy et al., 2005, as the distance from the point where the styloid left the tympanic plate to the tip of the process, regardless of whether or not the styloid process was segmented. The styloid process measuring more than 30mm was considered as elongated **(Ilgüy et al., 2005).** The type of elongation and calcification of each styloid process on both right and left sides were classified as per **Langlais et al., 1986,** with few modifications was reported by MacDonald – Jankowski, 2001, in his classification. Hence we modified Langlai's classification by adding a 4th variant of elongation pattern. It mainly included styloid process similar to type "H to J" patterns (proposed by MacDonald

– Jankowski DS) of calcified stylohyoid chain which was not continuous with the base of skull. The elongation patterns,Figure (1)

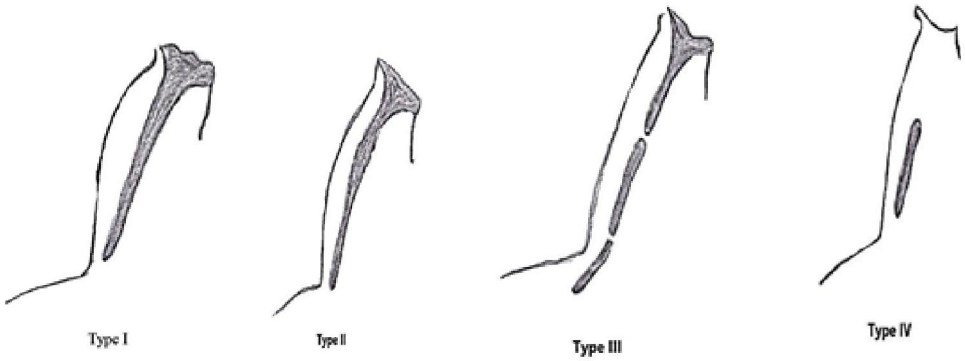


Figure (1) the elongation patterns

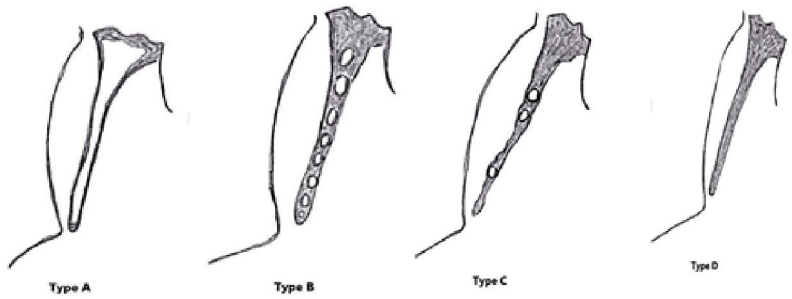
Were graded as:

Type I(Uninterrupted integrity of styloid process (>30mm)).

Type II (Styloid process joined to the mineralized stylomandibularor stylohyoid ligament by a single pseu-doarticulation).

Type III (segmented styloid processcontaining multiple pseudo articulations).

Type IV(elongation of styloid process due to distantossification).The calcificationpatterns, Figure(2).



Figure(2): The calcification patterns

Were divided into:
Type A (styloid process showing calcified outline).
Type B (partially calcified styloid process with discontinuousradiolucent core).
Type C (nodular appearance ofstyloid process with varying degree of central radiolucency.
Type D (completely calcified styloid processwith no evidence of a radiolucent interior).
The collected data was analyzed using, statisticalanalysis software SPSS version 16, Pearson´scorrelation test, ANOVA-test, F-test and Chi-square test were used to determine any significantdifferences between the groups.

3. Results:

The result of this study showed the mean and standard deviation of styloid process length of age groups in both panoramic and skyview images. The larger length were (36.11mm, 36.3mm) in panoramic and skyview images respectively. F- test between panoramic and skyview images length of the age groups demonstrated that statistically non-significant difference with (p-value = 0.759), table (1),figure (3) cleared that.

Chi-square of elongation patterns types in panoramic showed statistically significant difference between age groups with (p-value = 0.048), also in skyview images showed statistically significant difference of elongation patterns types between age groups with (p-value = 0.039).While chi-square of elongation patterns types between panoramic and skyview images by age showed statistically non-significant difference with (p-value = 0.989),as shown in tables (2,3). Chi-square of calcification patterns types in panoramic reported statistically significant difference between age groups with (p-value =0.042) and statistically significant difference between age groups in skyview images of calcification patterns types with (p-value = 0.047), also chi-square between panoramic and skyview images by age groups of calcification patterns typesdemonstrated statistically significant difference with (p-value = 0.046). While chi-square between panoramic and skyview images of calcification patterns types by age showed statistically non-significant difference with (p-value = 0.549), as shown in tables (4,5). Chi-square between elongation patterns types and calcification patterns types in panoramic showed statistically significant difference as same as in skyview images with (p-value = 0.042, p-value = 0.047) respectively. Chi-square between panoramic and skyview images by elongation patterns types and calcification patterns types of age groups showed statistically significant difference with (p-value = 0.049), while it showed statistically non-significant difference between panoramic and skyview images by elongation patterns types and calcification patterns types of age with(p-value = 0.423), tables (6,7) illustrated that. Pearson's correlation showed very strong statistically significant correlation between panoramic and skyview images of elongation types and calcification types (r=0.998, r=0.984) respectively, figure (4) illustrated that. While it showed strong statistically significant correlation between age and length of styloid process as same as the result between age and calcification types in both panoramic and skyview images (r=0.883, r=0.897) respectively, figure (5) illustrated that. Pearson's correlation showed highly moderate statistically non-significant correlation between panoramic and skyview images in both elongation types and calcification types by age groups (r=0.82, p-value=0.180; r=0.688, p-value=0.312) respectively, while it showed highly moderate statistically significant correlation between panoramic and skyview images in length of styloid process by age groups (r=0.872, p-value=0.048).

Table (1):Descriptive of styloid process length by age group

Skyview Length	Panoramic Length		No.	Age
33.61	33.25	Mean	4	>25
2.022	2.172	SD		
33.46	33.17	Mean	5	26-35
2.18	2.347	SD		
34.93	34.93	Mean	3	36-45
1.639	1.708	SD		
35.15	34.78	Mean	5	46-55
1.798	1.771	SD		
36.3	36.11	Mean	3	56-
1.289	1.378	SD		

ANOVA between panoramic and skyview images of styloid process length of age group
F-test =0.099; P=0.759, P>0.05 Non significant

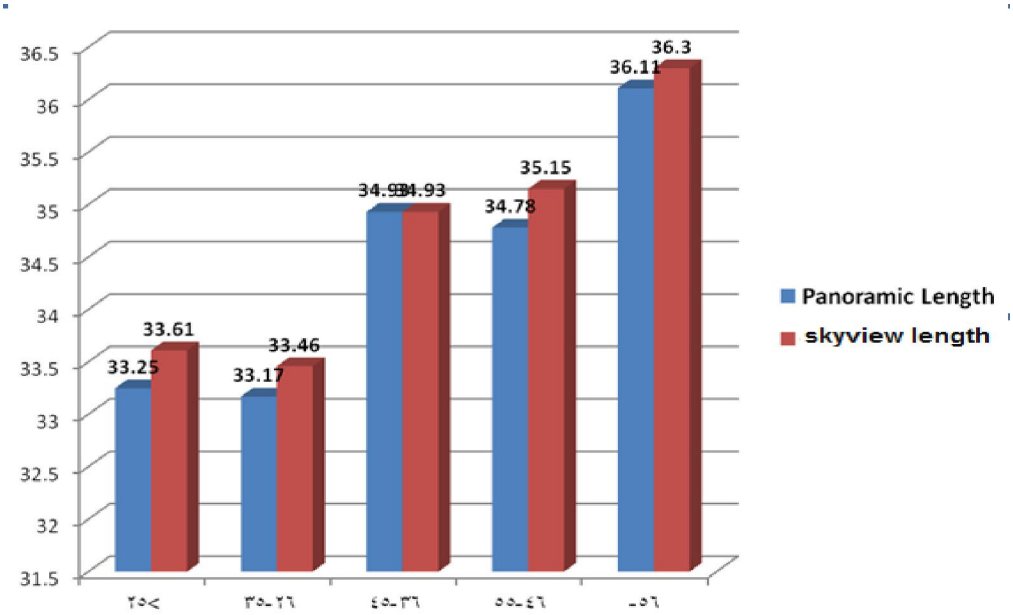


Figure (3):Show the length of styloid process of age groups in both panoramic and skyview images

Table(2):Show elongation pattern types of age groups in panoramic

Age	Elongation Pattern Types				
	Panoramic				
	TI	TII	TIII	TIV	Total
>25	5	2	0	1	8
26-35	6	2	1	1	10
36-45	4	1	0	1	6
46-55	9	1	0	0	10
56-	6	0	0	0	6
Total	30	6	1	3	40

***Chi-square=6.31; P=0.048, P<0.05, Significant**

Table(3):Show elongation patterns types of age groups in skyview images

Age	Elongation patterns Types				
	Skyview images				
	TI	TII	TIII	TIV	Total
>25	5	2	0	1	8
26-35	6	2	1	1	10
36-45	4	0	1	1	6
46-55	6	2	1	1	10
56-	6	0	0	0	6
Total	27	6	3	4	40

***Chi-square=8.53; P=0.39, P<0.05, Significant**
***Chi-square between Panoramic and skyview images of elongation patterns types by age groups.**
Chi-square=4.03; P=0.047, P<0.05, Significant
***Chi-square between Panoramic and skyview images of elongation types of Total**
Chi-square=0.099; p=0.989, P>0.05, Non Significant

Table(4):Show calcification patterns types of age groups in panoramic

Age	Calcification Pattern Types				Total
	Panoramic				
	TA	TB	TC	TD	
>25	1	1	1	5	8
26-35	2	1	1	6	10
36-45	1	1	1	3	6
46-55	3	1	0	6	10
56-	1	1	0	4	6
Total	8	5	3	24	40

***Chi-square=6.988; P=0.042, P<0.05, Significant**

Table(5):Show calcification patterns types of age groups in skyview images

Age	Calcification Pattern Types				Total
	Skyview images				
	TA	TB	TC	TD	
>25	1	1	1	5	8
26-35	1	1	2	6	10
36-45	1	1	1	3	6
46-55	2	1	1	6	10
56-	1	0	0	5	6
Total	6	4	5	25	40

***Chi-square=8.566; P=0.047, P<0.05, Significant**
***Chi-square between Panoramic and skyview images of calcification patterns types**
Chi-square=4.685; P=0.046, P<0.05, Significant

Table(6):Show distribution of elongation patterns types by calcification patterns types in panoramic

	Panoramic				
	TA	TB	TC	TD	Total
I	7	4	2	17	30
II	1	1	0	4	6
III	0	0	0	1	1
IV	0	0	1	2	3
Total	8	5	3	24	40

***Chi-square=6.223; P=0.042, P<0.05, Significant**

Table(7):Show distribution of elongation patterns types by calcification patterns types in skyview images

Skyview images					
	TA	TB	TC	TD	Total
I	4	3	4	16	27
II	1	0	0	5	6
III	0	1	1	1	3
IV	1	0	0	3	4
Total	6	4	5	25	40

***Chi-square=4.682; P=0.047, P<0.05, Significant**

***Chi-square between panoramic and skyview images elongation patterns types by calcification patterns types of age groups**

Chi-square=4.057; P=0.049, P<0.05, Significant

***Chi-square between Panoramic and skyview images elongation patterns types by calcification patterns types of Total**

Chi-square=6.02; p=0.423, P>0.05, Non Significant

Correlation between panoramic &skyview images of calcification patterns types r=0.984, p=0.016

Correlation between panoramic &skyview images of elongation patterns types r=0.998, p=0.001

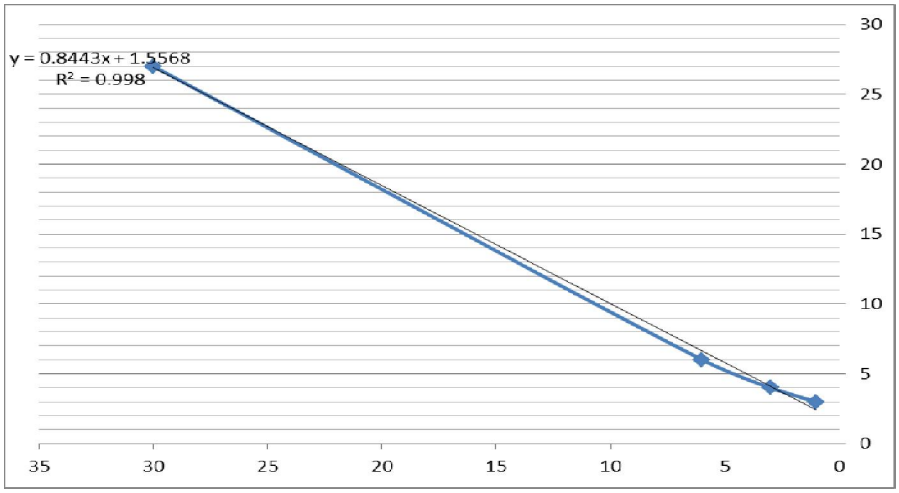


Figure (4): person correlation

there was high correlation positive between panoramicand skyview images of calcification types r= 0.998, p<0.01

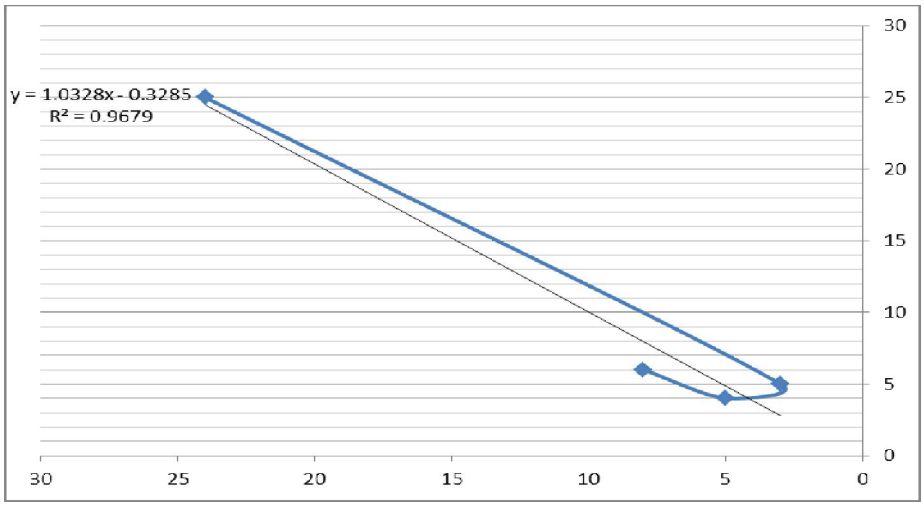


Figure (5) Person correlation between panoramic and skyview images of elongation types

4. Discussion:

Variation is the law of nature. Every human is unique anatomically to such an extent that even identical twins are not a like. This study performed a three-dimensional skyview to confirm the diagnosis of ossification of the stylohyoid ligament and the other relationship structures. It have been reported that three dimensional images is a suitable exam for defining anatomic associations, correct size, and angulation of the stylohyoid process (**Pereira et al., 2007)**.Furthermore, CBCT presents short scanning time, and radiation dose up to 15 times lower than multislice CT (MSCT) **(Scarfe et al.,2006).** The technology is becoming increasingly more available in dental and radiological practices **(Oliveira-Santos et al., 2011).**

This study found that the length, angle valueand morphological characteristics of the styloid process (SP) may be different in the same patient, so each SP must be evaluated separately.The actual cause of the elongation is a poorly understood process. Several theories have been proposed:

1) Congenital elongation of the styloid process due to persistence of a cartilaginous analog of the stylohyal (one of the embryologic precursors of the styloid).
2) Calcification of the stylohyoid ligament by an unknown process.
3) Growth of osseous tissue at the insertion of the stylohyoid ligament **(Balbuen et al., 1997).**The pathophysiological mechanism of symptoms is debated as well. Theories include the following:

1) Traumatic fracture of the styloid process causing proliferation of granulation tissue, which places pressure on the surrounding, structures **(Balasubramanian, 1964).**
2) Compression of adjacent nerves, the glossopharyngeal, lower branch of the trigeminal, or chorda tympani.
3) Degenerative and inflammatory changes in thetendonous portion of the stylohyoid insertion, called *insertion tendonitis*.
4) Irritation of the pharyngeal mucosa by direct compression or post-tonsillectomyscarring (involves cranial nerves V, VII, IX, and X).
5) Impingement of the carotid vessels,producing irritation of the sympathetic nerves in the arterial sheath (**Murtagh et al.,2001).**

In the present study showed increase calcification with age and it was more common in older age groups. Type I was more frequent type. Type III was observed more frequent in skyview compared with panoramic images, resolution of sky view cone beam computed tomography and accuracy was more that could be explained that. A study done by **Öztunç et al. in 2014,** to assess the structural characteristics of styloid process (SP).

by cone-beam computed tomography (CBCT) of 208 patients and they found that the most common morphology of SP was pseudoarticulated type (type II)and the most common pattern of ossification was partially calcified which was disagreed with the results of this study, this variation could be due to difference in the sample size or race. This study was in agreement with the results of a study done by **Reddy et al. in 2013**, to investigate the prevalence of elongation and calcification of styloid process in South India using panoramic radiographs which concluded that 154 styloid processes had length greater than 3 cm and type I was more prevalent in elder age group and with complete calcification (type D) was in most cases, also relatively high prevalent of type IV of elongation patterns 9/154 which approached with the result of present study 3/40 in panoramic and 4/40 in 3D panoramic images. **Bagga et al. in 2012** done a study to investigate the prevalence, morphology and calcification pattern of styloid process in the Mathura populations of India using panoramic radiographs of 2,706 adults and they found that calcification was more common with older age group and type I was observed more frequently which was in conformity with this study. **Anbiaee and Javadzadeh in 2011**,indicated continuous type as the most common type of morphology in their studies in which panoramic was used as diagnostic tool during a study done on 207 subjects(aged from9 to70 years) which was in conformity with finding of this study. This study partially conformed to the findings of **More and Asrani in 2010**, that type I was more frequent and disagreed with their finding that partially calcified was more common on study of 500 panoramic radiographs. **Başekim et al. in 2005,** determined the length of styloid process of 138 subjects (age ranged between 17-86 years) by three dimensional computed tomography and they found that the length varied between 1.58-5.48 cm while in this study maximum length in skyview images is3.63 cm this variation could be due to difference in the sample size or life style among people. In present study, the elongation of styloid process increased with the length as the age increased especially in skyview images and in panoramic was most commonly in age group 56+ this results was in agreement with the conclusion of a study done by **Priyadarshini et al. in 2013. Andrei et al. in 2013**, done a study to investigate the length and three-dimensional orientation of the styloid process in forty-four patients using cone beam computer tomography and they concluded that the morphometric and morphologic variations of the styloid processmay be important factors to be taken

into account not only from the viewpoint of styloid syndromes, but also in preparatory planning and during surgery.

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